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This report considers three aspects of base operating support (BOS) costs. Using statistical regression techniques, it provides models and identifies variables that can be used to predict BOS costs, compares BOS spending across services, and measures regional variations in BOS spending.

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TRI-SERVICE ANALYSIS OF BOS COSTS

Daniel B. Levine
Philip M. Lurie

CENTER FOR NAVAL ANALYSES

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CNR 73 / May 1984

TRI-SERVICE ANALYSIS OF BOS COSTS

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ABSTRACT

This report considers three aspects of base operating support (BOS) costs. Using statistical regression techniques, it provides models and identifies variables that can be used to predict BOS costs, compares BOS spending across services, and measures regional variations in BOS spending.

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SECTION 1

INTRODUCTION AND SUMMARY

This is a final report on several analyses of Base Operating Support (BOS) performed by the Center for Naval Analyses for the Office of the Secretary of Defense under contract N00014-82-C-0814 and Purchase Order N00014-84-M-0086.

BACKGROUND

In 1977, the Senate Appropriations Committee turned its attention to what the Department of Defense was spending to operate its military bases. To help in its investigations, the Committee asked DoD to begin collecting yearly data on BOS spending at all major bases in CONUS, Alaska, and Hawaii. Thus was established the Domestic Base Factors Report (DBFR).

In 1979, the Navy asked CNA to analyze the data on the 150 Navy installations represented in the DBFR. This research was reported in "The Determinants of Base Operating Support Costs" [1]. The principal result was a cost estimating relationship (CER) derived by statistical regression techniques. This CER predicted BOS spending across the spectrum of base types, using only 5 of the 70-odd base characteristics reported in the DBFR:

- The number of military personnel
- The number of civilian personnel
- The floor area of the buildings
- The acreage of the grounds
- The BTUs of energy consumed.

It was thus apparent that the DBFR was imposing a reporting burden on the services that exceeded the value of the information produced. OSD subsequently suspended the DBFR for review.

(The DBFR was not all bad. It was the only information system that reported data for all tenants of all services residing "within the fence." This is the only satisfactory way to report such common resources as base transportation, security, and road maintenance.)

The CNA study further showed that budget analysts could use the outliers of the CER--those bases spending much more than predicted--as a good "first cut" at which bases needed further budget scrutiny. This method proved more sensible than comparing bases according to the simple

ratio of "BOS cost per mission person" used by OSD in years past. The ratio method was therefore abandoned. The CER outliers were published in the CNA study as candidates for a closer look by Navy budget analysts.

CURRENT WORK FOR OSD

In 1982, OSD asked CNA for a similar analysis of DBFR data for all three military services. This work served as analytical support for the BOFM (Base Operations and Financial Management), an OSD and tri-service group that was studying ways to make military bases more efficient. In addition to developing statistical models for BOS cost for all three services, the research sought to determine what variables might be included in a future DBFR. This analysis is reported in section 2 below.

After this work was completed, the CNA study group was asked to help the Installations Management Study, another OSD and tri-service group, which was examining the pros and cons of consolidating the management of all services' bases in a single agency. We were asked to use the CER methodology to determine whether the three services are funding similar bases at about the same levels. This research is reported in section 3.

OSD also asked CNA to use the CERs to assess regional biases in BOS spending. The motivation for this task is a concern of the Northeast-Midwest Institute, which does research on the regional implications of federal policy initiatives, that DoD may spend more on the military bases in the South and West than on those in the Northeast and Midwest. This research is described in section 4.

In a related request, OSD asked CNA to identify several kinds of BOS activities that are also performed by the private sector and to compare the military and private spending levels. This analysis, which did not use CERs, and whose results are inconclusive, is being issued as "Comparison of Civilian and Military Overhead Spending" [2].

SUMMARY OF FINDINGS

Variables and Models To Predict BOS Costs

We find that a simple model using only seven base characteristics can predict 79-85 percent of BOS spending at military bases of all three services. These characteristics are:

- The number of mission (non-BOS) military personnel
- The number of mission (non-BOS) civilian personnel
- The number of dependents living in government housing

- The number of dependents living in non-government housing
- The floor area of the buildings
- The acreage of the grounds
- A weather variable indicating the need for heating and cooling.

To better understand the findings of this "reduced-form" model, section 2 develops a two-level hierarchical model that decomposes the relation of BOS cost to the base characteristics. The first level relates BOS cost to three BOS resources:

- The number of BOS military personnel
- The number of BOS civilian personnel
- The number of BTUs of energy consumed.

The second level then relates each of these BOS resources to the seven base characteristics.

The two models are complementary tools for budget analysis. The reduced-form model reveals which bases have been spending more than expected, given their characteristics, and the hierarchical model identifies whether the reason is that the base is using too many BOS resources or that it is spending too much money, given the BOS resources.

The implications of this research for a future DBFR are clear. Data for only a few variables need be collected: BOS cost, the seven base characteristics, and the three BOS resources. Asking the services to report additional variables would contribute more to the reporting burden than to useful knowledge.

Note, however, that because the models lack measures of BOS output (mission readiness and personnel retention), they give no insight into the ultimate questions of how much bases <u>should</u> spend for BOS activities and what the military services' total BOS budgets <u>should</u> be.

Comparison of BOS Spending Across Services

For this analysis, we first identified those types of bases that are common to all three services. These are bases with such primary missions as logistics and RDT&E. There were 180 DoD bases in this "common" set. Reduced-form regressions were then used to estimate how much each service would spend to operate the set of common bases. The Air Force proved 14 percent more costly than the Army or Navy, but in view of the roughness of the data and the aggregate nature of the models, this margin is insignificant.

The hierarchical model shows wide variations in the BOS resources used by the services, however. For an equivalent base, the Air Force uses many more BOS military personnel and BTUs of energy, and somewhat fewer civilian BOS personnel than the Army or Navy.

Regional Comparisons

DoD spends more in total dollars on bases in the South and West than in the Northeast and Midwest. But in terms of cost per base, and holding base characteristics constant, less is spent on the bases in the South and West than on those in the Northeast and Midwest.

SECTION 2

WHAT VARIABLES SHOULD A FUTURE DBFR REPORT?

INTRODUCTION

Our purpose was to find a small number of aggregate variables that can explain BOS spending of the approximately 400 domestic bases (CONUS plus Hawaii and Alaska) maintained by the Army, Navy, and Air Force. Marine Corps bases were excluded from the analysis because there are too few of them for good statistical reliability. The data were limited primarily to the variables reported by the 1980 DBFR.

Explaining BOS means fitting a model, and we tried two: a reduced-form model that indicates which bases are spending more than the population of bases as a whole, and a hierarchical model that helps to identify the causes.

REDUCED-FORM MODEL

The reduced-form model relates BOS cost to seven base characteristics (table 1). These seven characteristics are the ones we found to be strongly related to BOS cost on intuitive and statistical grounds. (The mission variable was added to see if the relationship depends on the type of base.) Many other likely candidates were considered and excluded for various reasons (table 2).

The results of fitting the reduced-form model to the data are shown in table 3. The mission variables have been placed below the line. The first column of table 3, for example, is read as follows ("ln" means natural logarithm and "e" is the base of natural logarithms):

$$\ln \text{BOS cost} = -1.78 + (0 \times \ln \text{MISSMIL}) + (0.13 \times \ln \text{MISSCIV}) + \ldots + (0.33 \times \text{ADM}) + \ldots + (0 \times \text{SMS}),$$

or

$$\text{BOS cost} = e^{-1.78}(\text{MISSMIL})^{0}\ (\text{MISSCIV})^{0.13} \ldots e^{0.33\text{xADM}} \ldots e^{0\text{xSMS}} .$$

If the base is an administrative one, for example, ADM = 1, and all the other mission variables are zero.

The reduced-form model meets the three criteria for a good fit. First, the coefficients of the base characteristics (above the line) have the expected positive sign. More mission military personnel, for example, mean more BOS cost. A negative sign for a mission variable (below the line) simply means the base has a lower BOS cost than does a logistics base, the excluded, or reference, dummy variable.

TABLE 1

REDUCED-FORM MODEL

BOS cost = f(MISSMIL, MISSCIV, DEPGH, DEPNGH, ACRE, AREA, WEATHER, MISSION),

where:

MISSMIL	=	number of military personnel assigned to missions[a]
MISSCIV	=	number of civilian personnel assigned to missions[b]
DEPGH	=	number of dependents living in government housing[c]
DEPNGH	=	number of dependents living in non-government housing[c]
AREA	=	total building area (thousands of square feet)[c]
ACRE	=	total land acreage of the base[c]
WEATHER	=	average annual heating plus cooling degree-days[d]
MISSION	=	base's primary mission[e].

---

[a]Total less BOS military personnel, from 1980 DBFR

[b]Total less BOS civilian personnel, from 1980 DBFR.

[c]From 1980 DBFR.

[d]From [3]. (A base's WEATHER is set equal to that of the closest city.)

[e]A combination of 0-1 ("dummy") variables representing a base's primary mission as listed in the 1983 Base Structure Annex:

ADM	Headquarters and administration
RDTE	Research, development, test, and evaluation
LOG	Logistics
SCH	School
CSI	Communications, security, or intelligence
AIR-T	Airfield, training
BASIC	Basic training
AIR-O	Airfield, operational
AIR-R	Airfield, reserve or national guard
MED	Medical center
FORT-I	Fort, infantry
FORT-M	Fort, mechanized, armored, or artillery
FORT-A	Fort, airborne
FORT-R	Fort, reserve or national guard
PROD	Production
NAVB	Naval base, surface or submarine
SY	Shipyard
PWC	Public works center
SMS	Strategic missile site

TABLE 2

VARIABLES EXCLUDED FROM REDUCED-FORM MODEL

<u>Variables tried and found not statistically significant</u>

Number of staff and faculty, military
Number of staff and faculty, civilian
Number of family housing units, occupied
Number of family housing units, not occupied
Number of military retirees
Average annual snowfall
Average annual temperature
Student average daily load

<u>Variables not tried, and reason</u>

Average age of buildings (data available for only a small sample of installations)
Number of buildings (ignores the size of buildings, which is captured by AREA)
Annual reserve component flying time (ignored in favor of a mission assignment variable for air and ground reserve bases)
Annual reserve component non-flying time (ignored for same reason)
Base mission codes listed in DBFR (according to service representatives, Base Structure Annex a more reliable source of primary mission)
Number of buildings used by school or training activities (ignores the size of buildings)
Area of buildings used for school or training activities (schools and training bases handled as an explicit mission category)
BOS cost components (ignored because of their formal relationship to total BOS cost)
Backlog of maintenance and repair (not an objective variable)
Military construction (ignored because related to new missions, not support of existing missions)

TABLE 3

REDUCED-FORM MODEL FOR BOS COST

BOS cost = f(base characteristics, missions)

	Army		Navy		Air Force	
Variable	Coefficient	t	Coefficient	t	Coefficient	t
Constant	-1.78	-2.07***	-2.60	-2.34	-3.04	-2.73***
ln MISSMIL	0	0	0.01	0.23	0.15	2.36***
ln MISSCIV	0.13	2.41**	0.11	2.60**	0.23	4.20***
ln DEPGH	0.09	2.18**	0	0	0	0
ln DEPNGH	0.10	3.96***	0.04	1.75*	0.05	1.97*
ln AREA	0.27	2.77***	0.36	5.87***	0.05	0.46
ln ACRE	0.05	1.68*	0.09	3.08***	0.05	1.28
ln WEATHER	0.02	0.27	0.13	1.01	0.32	2.77***
ADM	0.33	1.40	0.88	1.62	0.05	0.11
RDTE	0.27	1.36	0.38	2.35**	0.09	0.39
LOG[a]						
SCH	0.22	1.00	-0.19	-0.92	0.25	0.85
CSI	0.21	0.40	-0.23	-1.14*	-0.19	-0.56
AIR-T	0.36	0.67	0.13	0.63	-0.05	-0.25
BASIC	0.38	1.84*	0.21	0.74	--	--
AIR-O	--	--	0.40	2.09**	-0.10	-0.48
AIR-R	--	--	0.24	0.96	-0.18	-0.77
MED	-0.31	-0.98	0.37	1.80*	--	--
FORT-I	0.26	0.83	--	--	--	--
FORT-M	0.41	1.41	--	--	--	--
FORT-A	0.38	0.89	--	--	--	--
FORT-R	-0.06	-0.24	--	--	--	--
PROD	0.65	2.54**	--	--	--	--
NAVB	--	--	0.37	1.98*	--	--
SY	--	--	0.86	4.08***	--	--
PWC	--	--	1.17	3.24***	--	--
SMS	--	--	--	--	-0.29	-1.17
R^2	0.85		0.82		0.79	

Levels of statistical significance:
* 10%
** 5%
*** 1%.

[a]Reference dummy variable.

Second, the t-statistics indicate that the coefficients of the characteristics are statistically significant, many at high levels and some for all services. This means the variables are definitely related to BOS cost.

Finally, the values of R^2 shown at the bottom of the table are high--around 0.80--meaning that only 20 percent of the variability in BOS cost remains unexplained.

We conclude that if OSD wishes to institute a future reporting system for purposes of constructing a BOS cost estimating relationship, the seven base characteristics would be enough to obtain a good statistical explanation. The mission variables could be omitted because of their generally low statistical significance. Adding them would be little work, however, since they could be entered once and changed only rarely, when a base changes its primary mission.

HIERARCHICAL MODEL

The two-level hierarchical model decomposes the variation in BOS cost across bases into two kinds of factors (table 4). The first level relates BOS cost to three primary BOS resources for which BOS cost is spent, and the second level takes each of these BOS resources and relates them to the seven base characteristics used in the reduced-form model.

TABLE 4

HIERARCHICAL MODEL FOR BOS COST

<u>First level: BOS cost vs. BOS resources</u>

BOS cost = f(BOSMIL, BOSCIV, BTU, MISSION),

where:

BOSMIL = number of military personnel assigned to BOS tasks
BOSCIV = number of civilian personnel assigned to BOS tasks
BTU = number of BTUs of energy used for utilities
MISSION = base's primary mission[a]

<u>Second level: BOS resources vs. base characteristics[b]</u>

BOSMIL = f(MISSMIL, MISSCIV, DEPGH, DEPNGH, ACRE, MISSION)
BOSCIV = f(MISSMIL, MISSCIV, DEPGH, DEPNGH, AREA, MISSION)
BTU = f(MISSMIL, MISSCIV, AREA, WEATHER, MISSION)

---

[a]See table 1, footnote e for definitions.
[b]See table 1 for definitions of characteristics.

The statistical results for the hierarchical model are given in tables 5A-5D. As before, all dependent and independent variables except the mission variables are in natural logs, and the mission variables are set underneath the line.

The hierarchical model fits the data well. The coefficients of the BOS resources in the first-level equations (table 5A) have the expected positive sign: more BOS resources, more BOS cost. The occasional negative signs in the second-level equations are not troubling. In the last column of table 5B, for example, there is no logical reason why Air Force bases with larger numbers of mission civilians (MISSCIV) cannot have smaller numbers of BOS military personnel (BOSMIL).

The above-the-line variables in both levels of the hierarchical model are statistically significant, some for more than one service. The exception is energy consumption (BTU) in the first-level equation, but its t-statistic of 1.58 (Air Force) is just short of significance at the 10 percent level. Finally, the values of R^2 are high for all services and at both levels. The mission variables generally lack significance and add only a few percentage points to the values of R^2 obtained using the other variables alone.

BOS cost can thus be fairly well predicted by only three BOS resources, and these resources by only seven base characteristics.

USE OF THE REDUCED FORM AND HIERARCHICAL MODELS FOR BUDGETING

The reduced-form and hierarchical models can help budget analysts allocate BOS funds across services and across bases within an individual service. The function of the equations would be to serve as cost deflators, identifying those bases that are spending more than others.

To illustrate, imagine two Army bases that have identical characteristics, but base A has been spending a lot more than base B. To determine what budget action to take, the OSD (or service) budget analyst ideally needs information on BOS outputs--mission readiness and personnel retention. Then, if base A were spending above the efficient level and base B were underspending, reallocation from A to B would be indicated. If both bases were underspending, an increase in the combined BOS budget might be needed. Overspending by both would suggest budget cuts for both.

Normally, however, the budget analyst lacks systematic information on outputs. He knows when there is an entirely new base, or when there is a new mission or a major deficiency at an existing base. But DoD has no reporting system that generates aggregate, systematic information on outputs for the hundreds of Army, Navy and Air Force bases. In addition, the total DoD (or service) BOS budget is usually fixed by higher-level considerations.

TABLE 5A

HIERARCHICAL MODEL: FIRST LEVEL

BOS cost = f(BOS resources, missions)

	Army		Navy		Air Force	
Variable	Coefficient	t	Coefficient	t	Coefficient	t
Constant	-2.33	-2.27**	-2.36	-2.37**	-2.16	-2.67***
ln BOSMIL	0.13	1.44	0.14	2.07**	0.05	0.91
ln BOSCIV	0.49	2.26**	0.52	3.54***	0.52	3.81***
ln BTU	0.14	0.88	0.12	0.85	0.15	1.58
ADM	0.06	0.23	0.04	0.06	-0.03	-0.59
RDTE	0.03	0.16	0.15	0.97	0.01	0.05
LOG[a]						
SCH	0.08	0.28	0.02	0.09	0.09	0.31
CSI	-0.09	-0.20	0.02	0.08	0.18	0.45
AIR-T	0.12	0.22	-0.02	-0.09	-0.24	-1.29
BASIC	0.10	0.41	0.09	0.28	--	--
AIR-O	--	--	0.16	0.65	-0.09	-0.45
AIR-R	--	--	-0.12	-0.45	-0.04	-0.15
MED	-0.04	-0.11	-0.12	-0.62	--	--
FORT-I	0.16	0.43	--	--	--	--
FORT-M	0.11	0.35	--	--	--	--
FORT-A	0.16	0.36	--	--	--	--
FORT-R	-0.09	-0.39	--	--	--	--
PROD	0.12	0.44	--	--	--	--
NAVB	--	--	0.07	0.32	--	--
SY	--	--	0.21	0.89	--	--
PWC	--	--	-0.01	-0.02	--	--
SMS	--	--	--	--	-0.26	-1.04
R^2	0.97		0.89		0.81	
R^2 without mission variable	0.97		0.81		0.80	

Levels of statistical significance:
* 10%
** 5%
*** 1%.

[a]Reference dummy variable.

TABLE 5B

HIERARCHICAL MODEL: SECOND LEVEL

BOSMIL = f(mission resources, mission dummies)

	Army		Navy		Air Force	
Variable	Coefficient	t	Coefficient	t	Coefficient	t
Constant	-0.41	-0.57	0.52	1.04	1.14	1.44
ln MISSMIL	0.11	1.14	0.31	4.38***	0.80	7.84***
ln MISSCIV	0.02	0.22	0.04	0.71	-0.24	-2.82***
ln DEPGH	0.31	4.31***	0.05	1.03	0.13	2.48***
ln DEPNGH	0.22	4.39***	0.07	1.90	0.06	1.25
ln ACRE	0.08	1.67*	0.17	3.67***	-0.05	-0.73
ADM	1.25	2.65***	0.11	0.13	-0.80	-1.07
RDTE	0.25	0.73	-0.26	-0.95	0.08	0.21
LOG[a]						
SCH	0.86	1.97*	-0.08	-0.21	0.88	1.62
CSI	1.23	1.57	0.25	0.72	0.97	1.56
AIR-T	0.84	0.79	0.64	1.71*	0.16	0.45
BASIC	1.24	3.04***	0.87	1.74*	--	--
AIR-O	--	--	1.04	3.04***	0.08	0.22
AIR-R	--	--	1.11	2.59***	-1.72	-4.06***
MED	-1.25	-1.98*	0.56	1.58	--	--
FORT-I	0.70	1.13	--	--	--	--
FORT-M	0.86	1.50	--	--	--	--
FORT-A	0.71	0.84	--	--	--	--
FORT-R	0.04	0.08	--	--	--	--
PROD	0.37	0.73	--	--	--	--
NAVB	--	--	0.79	2.40**	--	--
SY	--	--	0.19	0.51	--	--
PWC	--	--	1.15	2.07**	--	--
SMS	--	--	--	--	0.27	0.60
R^2	0.85		0.75		0.94	
R^2 without mission variable	0.81		0.68		0.90	

Levels of statistical significance:
* 10%
** 5%
*** 1%.
[a]Reference dummy variable.

TABLE 5C

HIERARCHICAL MODEL: SECOND LEVEL

BOSCIV = f(mission resources, mission dummies)

Variable	Army Coefficient	Army t	Navy Coefficient	Navy t	Air Force Coefficient	Air Force t
Constant	0.34	0.47	0.31	0.68	1.14	1.68*
ln MISSMIL	-0.07	-1.08	-0.04	-0.80	0.06	0.80
ln MISSCIV	0.14	2.21**	0.20	3.63***	0.32	5.06***
ln DEPGH	0.14	2.52**	0.06	1.51	0.03	0.71
ln DEPNGH	0.13	3.95***	0.04	1.48	0.07	2.39**
ln AREA	0.47	4.38***	0.53	6.97***	0.25	2.06**
ADM	0.11	0.34	1.34	1.88*	0.07	0.14
RDTE	0.35	1.39	0.47	2.21**	0.07	0.30
LOG[a]						
SCH	-0.07	-0.23	-0.75	-2.85***	0.19	0.54
CSI	-0.11	-0.21	-0.66	-2.47**	-0.50	-1.24
AIR-T	0.30	0.41	0.18	0.67	0.36	1.58
BASIC	0.19	0.67	-0.46	-1.25	--	--
AIR-O	--	--	0.11	0.41	0.01	0.02
AIR-R	--	--	0.28	0.87	-0.02	-0.09
MED	-0.59	-1.39	0.24	0.91	--	--
FORT-I	-0.13	-0.32	--	--	--	--
FORT-M	0.28	0.71	--	--	--	--
FORT-A	0.16	0.27	--	--	--	--
FORT-R	-0.07	-0.22	--	--	--	--
PROD	0.66	1.90*	--	--	--	--
NAVB	--	--	0.01	0.05	--	--
SY	--	--	0.75	2.69***	--	--
PWC	--	--	2.38	5.01***	--	--
SMS	--	--	--	--	0.02	0.07
R^2	0.80		0.83		0.81	
R^2 without mission variable	0.77		0.71		0.79	

Levels of statistical significance
* 10%
** 5%
*** 1%.
[a]Reference dummy variable.

TABLE 5D

HIERARCHICAL MODEL: SECOND LEVEL

BTU = f(mission resources, mission dummies)

Variable	Army Coefficient	Army t	Navy Coefficient	Navy t	Air Force Coefficient	Air Force t
Constant	4.39	3.95***	0.63	0.40	-1.16	-0.99
ln MISSMIL	0.15	3.24***	0.11	2.30**	0.04	0.65
ln MISSCIV	0.14	2.21**	0.20	3.35***	0.12	2.08**
ln AREA	0.65	7.18***	0.45	5.31***	0.82	7.93***
ln WEATHER	0.10	0.96	0.72	4.00***	0.74	5.99***
ADM	0.11	0.38	-0.95	-1.17	0.03	0.06
RDTE	0.71	2.83***	0.35	1.47	0.57	2.59**
LOG[a]						
SCH	0.41	1.41	0.16	0.54	0.08	0.25
CSI	0.83	1.20	0.21	0.70	0.10	0.27
AIR-T	0.47	0.66	0.30	0.96	0.21	1.01
BASIC	0.45	1.72*	0.36	0.86	--	--
AIR-O	--	--	0.38	1.33	0.10	0.48
AIR-R	--	--	0.31	0.86	-0.19	-0.76
MED	0.72	1.76*	0.64	2.29**	--	--
FORT-I	0.45	1.09	--	--	--	--
FORT-M	0.52	1.39	--	--	--	--
FORT-A	0.55	0.98	--	--	--	--
FORT-R	0.20	0.67	--	--	--	--
PROD	1.11	3.26***	--	--	--	--
NAVB	--	--	0.34	1.24	--	--
SY	--	--	1.27	4.10***	--	--
PWC	--	--	0.26	0.48	--	--
SMS	--	--	--	--	0.32	1.24
R^2	0.81		0.75		0.88	
R^2 without mission variable	0.77		0.71		0.85	

Levels of statistical significance:
* 10%
** 5%
*** 1%.

[a]Reference dummy variable.

Thus, the total BOS budget and the characteristics of the various bases are the only systematic data at the budget analyst's fingertips. In the case of the two identical Army bases with different budgets, the analyst's best decision would probably be to equalize the funding. Even granting the claim that U.S. military bases are in poor repair, they still probably fall in the region where increasing expenditures bring lower returns on the margin. The Army would thus gain overall by taking money from base A (higher spending) and giving it to base B (lower spending).

But suppose the two bases do not have the same characteristics. Say base A has more personnel and buildings to support. The budget analyst needs to adjust for this disparity before comparing the spending level of the two bases. This is what the reduced-form model accomplishes. It yields a predicted level of spending that a base of given characteristics would have if it were "in step" with the costs and characteristics of the population of bases as a whole.

To apply the model, the budget analyst would use the reduced-form equation to calculate the "residual" of each base: how much the base is spending over or under the predicted level. To equalize spending, he would shift funds from bases with large positive residuals (those spending much more than predicted) to those with large negative residuals (those spending much less than predicted).

The hierarchical model could be used to further refine these budgetary reallocations. If a base has a large positive residual using the reduced-form equation, the residuals from the hierarchical model would indicate whether the base was spending more BOS, given its BOS resources, or whether it was using more BOS resources, given its characteristics.

SECTION 3

COMPARISON OF BOS SPENDING ACROSS SERVICES

INTRODUCTION

Lacking systematic measures of BOS output, the military services have been relying on more intuitive methods of deciding how much to spend on their bases. A service may use "management by calamity," the "squeaky wheel" approach, or similar methods in allocating its total BOS budget across bases. But decisions on what this total BOS budget should be are based on more general policy considerations. (By exception, the Navy is now developing a readiness reporting system as a way of injecting output information into the budget process.)

The question for this section is whether the services have different policies--that is, whether they are spending different amounts on similar bases. The statistical models developed in the previous chapter can be used to estimate these cost differences. If one service is spending less than the others, that would suggest it has discovered efficiencies that the other services might copy. (It is also possible, however, that the cheaper base is less effective in supporting its missions.)

The starting point for the analysis is to identify those types of bases, such as logistics bases, that are operated by all three services. These base types are listed under "All services" in table 6. We think of these bases as simply a set of common DoD bases, ignoring who owns them.

We then go to each service in turn and use its reduced-form regression to estimate how much that service would spend in operating the bases in the common set. For example, the Army regression, which predicts how much the Army has been spending to operate its own bases, can also be used to predict how much the Army would spend to operate a Navy base. We simply put the Navy base's characteristics and mission into the Army equation. In this fashion, the Army equation is used to estimate how much the Army would spend to operate the entire set of common bases.

The same procedure is followed for all three services. Since the set of bases is held constant, any differences in total spending among the services are due to differences in BOS management policy. Having used the reduced-form model to compare BOS spending, we repeat the procedure with the hierarchical model to help isolate the reasons for the differences.

TABLE 6

MISSIONS OF MILITARY BASES[a]

Primary mission		Army	Navy	Air Force	Total
		Number of bases			
All services					
ADM	Headquarters and administration	11	1	1	13
RDTE	Research, development, test, and evaluation	16	17	8	41
LOG	Logistics	22	23	8	53
SCH	School	12	13	2	27
CSI	Communications, security, or intelligence	2	18	2	22
AIR-T	Airfield, training	1	9	14	24
Two services					
BASIC	Basic training	16	14	--	20
AIR-O	Airfield, operational	--	14	47	61
AIR-R	Airfield, reserve or national guard	--	6	19	25
MED	Medical center	4	16	--	20
One service					
FORT-I	Fort, infantry	5	--	--	5
FORT-M	Fort, mechanized, armor, or artillery	8	--	--	8
FORT-A	Fort, airborne	2	--	--	2
FORT-R	Fort, reserve or national guard	10	--	--	10
PROD	Production	5	--	--	5
NAVB	Naval base, surface or submarine	--	18	--	18
SY	Shipyard	--	8	--	8
PWC	Public works center	--	6	--	6
SMS	Strategic missile site	--	--	9	9
	Service totals	114	163	110	377

[a]Sources: 1980 DBFR for list of bases.
1983 Base Structure Annex for primary mission.

RESULTS

Figure 1 displays the results of the analysis. (Detailed results by type of base are listed in tables 7 and 8 at the end of this section.) The curve labeled "BOS costs: Reduced-form model," for example, indicates that if the Army were to manage all the common bases in the same way it is currently managing its own bases, it would spend about $5.0 billion for BOS. (See table 7, the entry in the column marked "Army" and the row marked "Common.")

The figure shows that the Navy would operate the common bases at about the same funding level as the Army, and the Air Force would spend about 14 percent more.

We regard these results as a "tie." Given the roughness of the data and the incompleteness of the model, there is no strong evidence that the services are managing their bases at different cost levels. Their actual budgets differ, but the differences vanish when we hold base characteristics and missions constant.

Although the total costs for the common set of bases are similar, the services do use much different mixes of BOS resources. They would all use about the same number of BOS civilians to operate the common set (figure 1 and table 8C), but the Air Force would use well over 100 percent more BOS military personnel (table 8B) and about 50 percent more BTUs of power (table 8D) than the Army and Navy. Air Force officers say their large use of BOS military personnel is no surprise. The Air Force has a deliberate policy of recruiting many officers and enlisted personnel for wartime mobilization and using them for BOS during peacetime. In wartime, although the Air Force deploys forward, it must maintain an active domestic establishment as well.

Note, however, that <u>given</u> the BOS resources they use, the three services would spend about the same: The curve "BOS costs: Hierarchical model" is fairly flat. This is understandable. Military and civil-service pay scales are about the same across bases (the regional differences in housing allowances are small compared to total compensation), and there is a national market for oil and natural gas.

Why do the large differences in BOS resources produce so little difference in BOS costs? We can explain some of this discrepancy by using the statistical calculations. The regression coefficients show that BOS cost is most sensitive to the number of BOS civilians, and table 8C shows that the Air Force uses about 7 percent less of this resource than the other services. This is enough to almost cancel out the Air Force's much greater use of BOS military personnel and BTUs of power (calculation not shown).

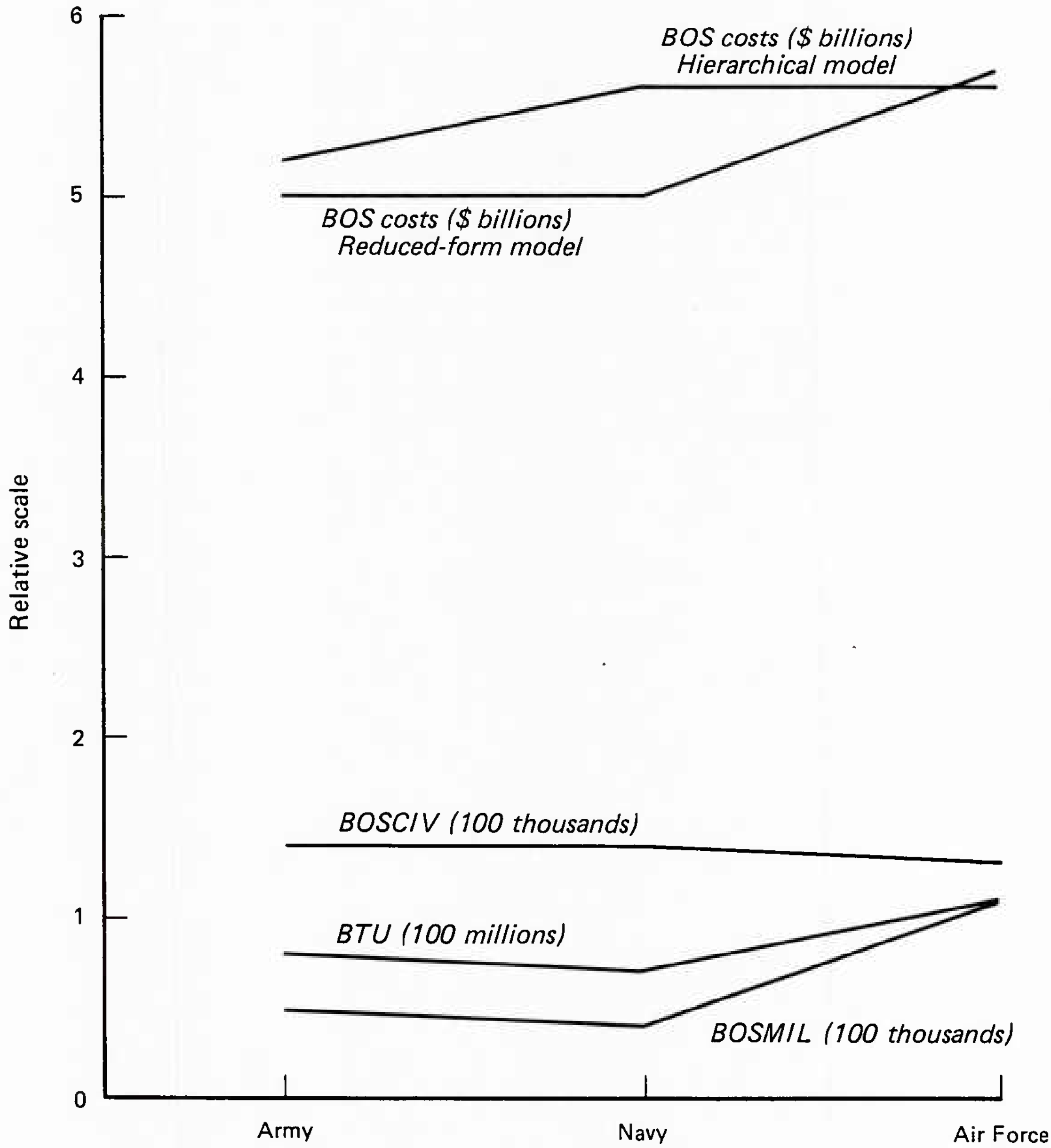

FIG. 1: TRI-SERVICE ESTIMATES OF BOS COSTS AND BOS RESOURCES TO MANAGE 180 "COMMON" BASES

In a more practical sense, however, it is still suspicious that although the services use widely different compositions of BOS resources, the relative costs for these resources cancel out and produce no overall differences in spending. Perhaps the services are equally frugal.

It is also possible that a more careful cost analysis would destroy the apparent equality in BOS spending. In reporting BOS costs in the DBFR, the services have likely overstated the spending for civilians relative to military personnel. Retirement contributions to civilian contractors and direct hires are visible, out-of-pocket expenses that installation budget comptrollers "see." Civilian pay, moreover, includes contributions for the medical plan and compensation for housing (through the labor supply curve). By contrast, retirement costs for military personnel are an expenditure that DoD does not even request from Congress until needed, and military personnel receive "uncaptured" payments in kind for medical care and on-base housing.

The services might appear equally frugal in BOS spending using the personnel costs that they see, but they may not be equally so if full costs were calculated.

TABLE 7

REDUCED-FORM MODEL

BOS COSTS OF COMMON BASES
($ millions)

	Army	Navy	Air Force
ADM	458	651	451
RDTE	1,098	1,363	1,252
LOG	1,174	1,416	1,700
CSI	148	102	185
SCH	895	502	1,174
AIR-T	1,216	925	926
BASIC	1,088	730	--
MED	151	272	--
AIR-O	--	2,965	2,270
AIR-R	--	340	286
Common	4,989	4,959	5,688
Common + BASIC + MED	6,228	5,961	--
Common + AIR-O + AIR-R	--	8,264	8,244

TABLE 8A

HIERARCHICAL MODEL: FIRST LEVEL

BOS COSTS OF COMMON BASES
($ millions)

	Army	Navy	Air Force
ADM	456	489	459
RDTE	1,182	1,456	1,387
LOG	1,385	1,491	1,703
CSI	109	128	170
SCH	925	954	1,033
AIR-T	1,154	1,095	856
BASIC	1,041	1,132	--
MED	262	252	--
AIR-O	--	3,073	2,246
AIR-R	--	308	308
Common	5,211	5,613	5,608
Common + BASIC + MED	6,514	6,997	--
Common + AIR-O + AIR-R	--	8,994	8,162

TABLE 8B

HIERARCHICAL MODEL: SECOND LEVEL

BOSMIL OF COMMON BASES
(Numbers of people)

	Army	Navy	Air Force
ADM	7,902	2,836	4,343
RDTE	6,154	5,808	11,225
LOG	4,381	6,405	11,462
CSI	2,693	1,781	12,592
SCH	12,808	6,713	46,910
AIR-T	14,567	14,754	26,382
BASIC	21,194	20,981	--
MED	443	2,871	--
AIR-O	--	62,841	93,383
AIR-R	--	4,624	503
Common	48,505	38,297	112,914
Common + BASIC + MED	70,142	62,149	--
Common + AIR-O + AIR-R	--	105,762	206,800

TABLE 8C

HIERARCHICAL MODEL: SECOND LEVEL

BOSCIV OF COMMON BASES
(Numbers of people)

	Army	Navy	Air Force
ADM	11,824	32,232	10,884
RDTE	34,577	36,733	26,885
LOG	40,489	42,812	40,828
CSI	2,723	1,459	1,987
SCH	21,477	8,775	24,460
AIR-T	32,385	22,118	29,419
BASIC	27,326	11,325	--
MED	3,455	6,161	--
AIR-O	--	51,096	50,761
AIR-R	--	7,719	5,651
Common	143,475	144,129	134,463
Common + BASIC + MED	174,256	161,615	--
Common + AIR-O + AIR-R	--	202,944	190,875

TABLE 8D

HIERARCHICAL MODEL: SECOND LEVEL

BTUs OF COMMON BASES
(Millions)

	Army	Navy	Air Force
ADM	5	2	6
RDTE	20	16	29
LOG	18	20	36
CSI	3	2	2
SCH	15	12	17
AIR-T	15	13	17
BASIC	17	13	--
MED	5	5	--
AIR-O	--	38	45
AIR-R	--	5	4
Common	76	65	107
Common + BASIC + MED	98	83	--
Common + AIR-O + AIR-R	--	108	156

SECTION 4

REGIONAL BIASES IN DOD SPENDING ON BASE OPERATIONS

FINDINGS

The Northeast-Midwest Institute is concerned that DoD's spending for military installations has been favoring the South and West regions of the country at the expense of the Northeast and Midwest. This section examines this claim. Our findings are summarized in table 9. We will discuss them and then show where they came from. The section ends with a graphic comparison of spending in the two regions.

TABLE 9

REGIONAL BIASES IN DOD SPENDING FOR BOS

	Northeast-Midwest ($ millions)	South-West ($ millions)	Margin of South-West over Northeast-Midwest (percent)
Total BOS spending	2,800	9,240	230
BOS spending per base holding base characteristics constant			-9

In terms of total spending, DoD certainly does spend more in the South and West. However, that is where most of the bases are. Additionally, we have to consider the fact that different bases have different characteristics--different acreage, climate, building area, number of military personnel, etc. By using statistical regression techniques to hold base characteristics constant, we find that DoD spends <u>less</u> per base in the South and West than in the Northeast and Midwest.

CALCULATIONS

The entries on "Total BOS spending" in table 9 were calculated directly from data in the 1980 Domestic Base Factors Report (DBFR). We simply added up BOS spending for all bases of all services that were located in the two aggregate regions of interest, the Northeast-Midwest and South-West. For information, breakdowns of BOS spending and base distribution by region and service are shown in tables 10 and 11.

TABLE 10

BOS COSTS BY REGION AND SERVICE[a]
($ millions)

	New England	Mid-Atlantic	Midwest	Total Northeast-Midwest	South	West	Total South-West
Army	81	730	214	1,025	2,113	1,094	3,207
Navy	229	570	142	941	1,399	1,612	3,011
Air Force	103	281	452	836	1,449	1,571	3,020
Total	413	1,581	808	2,802	4,961	4,277	9,238

[a]Data from 1980 DBFR.

TABLE 11

NUMBER OF DOMESTIC BASES BY REGION AND SERVICE[a]

	New England	Mid-Atlantic	Midwest	Total Northeast-Midwest	South	West	Total South-West
Army	6	20	8	34	41	37	78
Navy	11	20	7	38	56	57	113
Air Force	5	9	14	28	40	42	82
Total	22	49	29	100	137	136	273

[a]Data from 1980 DBFR.

The second entry in table 9, which shows DoD spending 9 percent less per common base in the South and West than in the Northeast and Midwest, is more complicated. It estimates what the regional differences in spending would have been if all bases had had the same characteristics. (We are not asking why military bases are located where they are, but rather whether similar bases are being supported at different levels in the different regions.) Here are the steps:

1. Start with the reduced-form regressions developed in section 1 that relate BOS cost to various base characteristics.

2. Add auxiliary, or dummy, variables for the five basic regions. Repeat the regressions and note the coefficients of the regional dummy variables.

3. Use the distribution of bases in table 11 to weight these coefficients and form a DoD average for the two aggregate regions.

4. Convert these weighted coefficients to differences in predicted BOS cost.

The original reduced-form regressions are given in table 3 of section 2, and the new regressions with the regional dummy variables are shown in table 12 below. (The West is the excluded, or reference, dummy variable.) We will be discussing only the regional effects, and have put them below the second line for convenience.

The t-statistics of the regional variables give little confidence of a regional bias. One of the 12 coefficients passes the test of significance at the 5 percent level, but the remaining t-statistics are small. The increases in R^2 from table 3 in section 2 are less than one percentage point in each service. In short, the characteristics of the various bases seem to do a good job of predicting the variability in BOS cost across bases. Region adds little significant predictive power.

Despite their poor statistical showing, the coefficients of the regional dummy variables are still the best estimates we have of the numerical effect of region on BOS spending per base. We use the distribution of bases in table 11 as weights to determine an average coefficient for each aggregate region. Since the regressions are for each service, the averaging must be performed first over regions within a service, and then across services. To obtain the Northeast-Midwest average, for example, first calculate the weighted average for the Army:

$$[(6 \times 0.025) + (20 \times 0.367) + (8 \times 0.186)] \div 34 = 0.264 .$$

TABLE 12

REDUCED-FORM MODEL FOR BOS COST
INCLUDING REGIONAL VARIABLES

	Army		Navy		Air Force	
Variable	Coefficient	t	Coefficient	t	Coefficient	t
Constant	-1.86	-2.16**	-2.14	-1.36	-2.88	-2.33**
ln MISSMIL	0.01	0.19	0.01	0.28	0.15	2.33**
ln MISSCIV	0.12	2.17**	0.11	2.59**	0.20	3.63***
ln DEPGH	0.09	1.89*	0.01	0.17	0	0
ln DEPNGH	0.08	3.08***	0.04	1.69*	0.05	1.88*
ln AREA	0.26	2.55**	0.34	5.34***	0.09	0.72
ln ACRE	0.06	1.85*	0.09	2.94***	0.05	1.19
ln WEATHER	0.02	0.25	0.08	0.41	0.30	2.34**
ADM	0.39	1.59	0.90	1.56	0.01	0.02
RDTE	0.25	1.21	0.34	2.02**	0.11	0.50
LOG[a]						
SCH	0.24	1.08	-0.21	-0.97	0.23	0.77
CSI	0.11	0.20	-0.24	-1.15	-0.20	-0.56
AIR-T	0.39	0.71	0.13	0.61	-0.07	-0.37
BASIC	0.36	1.71*	0.22	0.74	--	--
AIR-O	--	--	0.41	2.08**	-0.15	-0.72
AIR-R	--	--	0.22	0.88	-0.19	-0.77
MED	-0.23	-0.71	0.34	1.62	--	--
FORT-I	0.37	1.16	--	--	--	--
FORT-M	0.47	1.58	--	--	--	--
FORT-A	0.39	0.90	--	--	--	--
FORT-R	-0.06	-0.23	--	--	--	--
PROD	0.62	2.34**	--	--	--	--
NAVB	--	--	0.31	1.59	--	--
SY	--	--	0.86	3.98***	--	--
PWC	--	--	1.24	3.29***	--	--
SMS	--	--	--	--	-0.38	-1.43
New England	0.025	0.10	0.022	0.11	-0.285	-1.41
Mid-Atlantic	0.367	2.27**	0.149	0.87	0.107	0.71
Midwest	0.186	0.86	-0.025	-0.10	0.058	0.39
South	0.170	1.25	0.033	0.27	-0.061	-0.66
West[a]						
R^2	0.85		0.82		0.80	

Levels of statistical significance:
* 10%
** 5%
*** 1%.

[a]Reference dummy variable.

The weighted averages for the Navy and Air Force are 0.080 and 0.013, respectively. Averaging over the three services then gives the DoD-wide average for the Northeast-Midwest:

$$[(112 \times 0.264) + (51 \times 0.080) + (110 \times 0.013)] \div 373 = 0.115 \ .$$

The average for the South-West is 0.024.

To translate these weighted coefficients into variations in BOS cost by region, first consider the form of the regressions we have been dealing with:

$$\ln \text{BOS cost} = a + b(\ln s) + c_1(r_1) + c_2(r_2) + \ldots \ ,$$

where:

s stands for the "size" independent variables (building area, number of personnel, etc.),

r_1, r_2, ... are dummy variables for region:

$r_1 = 1$ (all others 0) is New England,

$r_2 = 2$ (all others 0) is Middle Atlantic,

etc.

a, b, c_1, c_2, ... are constants determined by regression.

Take the exponential of both sides:

$$\text{BOS cost} = e^a \times s^b \times e^{c_1 r_1 + c_2 r_2 + \ldots} \ .$$

As an example:

$$\text{BOS cost for New England} = e^a \times s^b \times e^{c_1} \ ,$$

$$\text{BOS cost for Middle Atlantic} = e^a \times s^b \times e^{c_2} \ ,$$

and:

$$(\text{BOS cost New England})/(\text{BOS cost Middle Atlantic}) = e^{c_1 - c_2} \ .$$

In other words, subtracting the coefficients of any two regional dummies and taking the exponential of the result gives the ratio between the two values of BOS cost for those regions. For the two aggregate regions of interest, the difference is 0.024 - 0.115 = -0.09 (South-West less Northeast-Midwest), and the exponential of -0.09 is 0.91. Thus, holding base characteristics constant, the South-West is receiving

9 percent less BOS per base than the Northeast-Midwest, as shown in table 9.

GRAPHIC ANALYSIS

Figure 2 presents a graphic comparison of BOS spending in the two regions. The figure deals with the "residuals" of the regression equation: the difference between what each base actually spends (as given by the raw data) and what a typical base with those same characteristics would spend (the "predicted" spending level given by the regression equation). For this analysis, we used the regressions without the regional dummy variables. There would be no point in using dummy variables to account for regional differences, and then measuring the deviations from the adjusted equations.

Since the regressions involve logarithms, the difference between "actual" and "predicted" is expressed in ratio form. For example, the peak of the Northeast-Midwest curve indicates that 39 percent of the bases in that region are spending within 20 percent of the amount predicted by the regression. That is, the ratio of actual to predicted BOS cost lies between 0.80 and 1.20. These bases are thus spending about what we would expect, given the pattern of spending for all the bases taken together. The next point to the right indicates that 26 percent of the bases are spending from 20 to 60 percent more than expected, and so on. A summary of the graph is given in table 13.

TABLE 13

COMPARISON OF BOS SPENDING IN THE NORTHEAST-MIDWEST AND SOUTH-WEST REGIONS

	Northeast-Midwest (percent)	South-West (percent)
Bases spending lower than predicted	22	27
Bases spending about as predicted[a]	39	44
Bases spending higher than predicted	39	29
	100	100

[a]Within 20 percent.

The distributions for the two regions lie fairly close together. In each, many of the bases are spending about as predicted (i.e., within 20 percent either way), some are spending more and some less, and the distribution is roughly the same in the two regions.

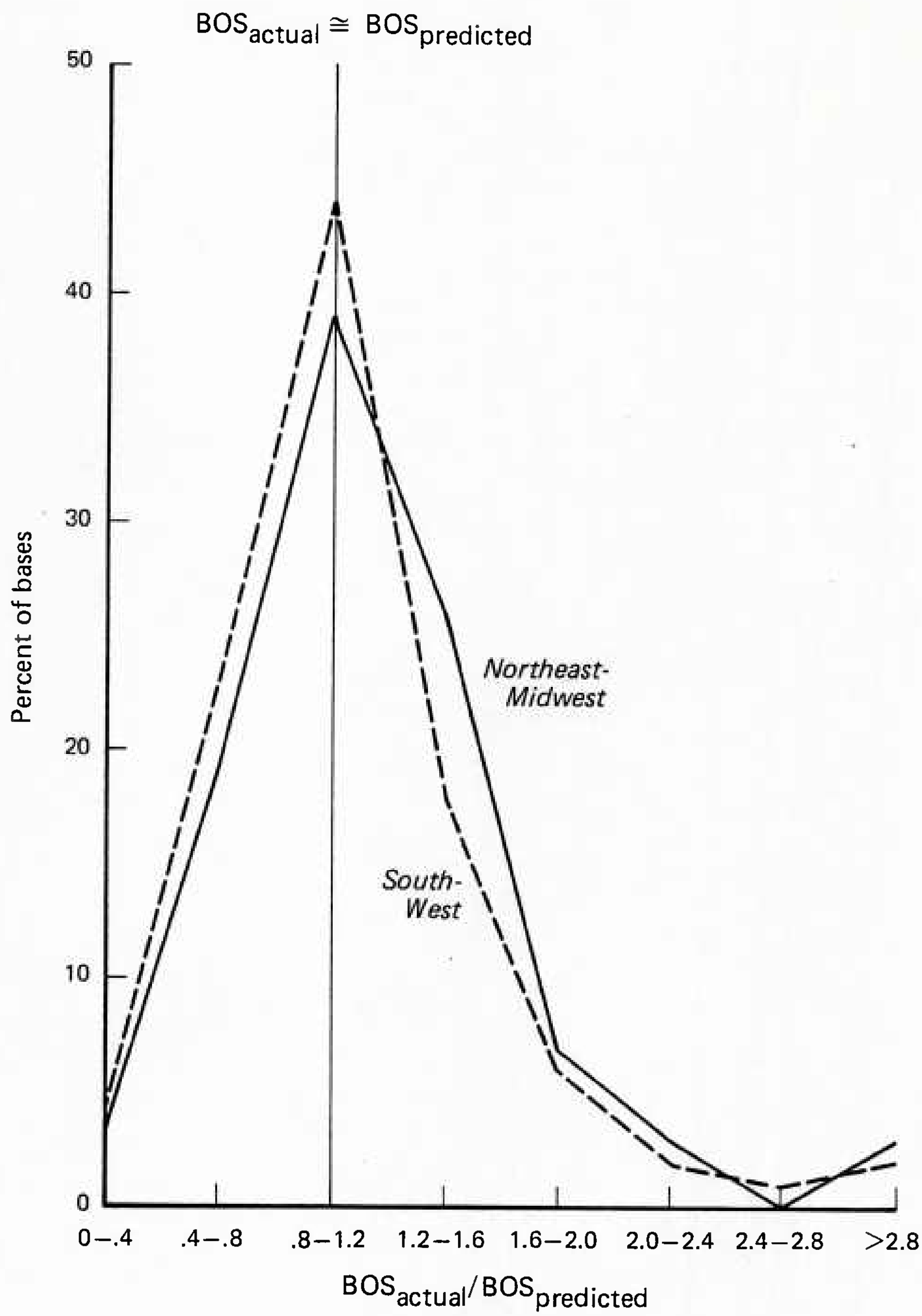

FIG. 2: DISTRIBUTION OF REGRESSION RESIDUALS

There is, however, a noticeable skewness between the two distributions. The Northeast-Midwest curve lies somewhat to the right of the South-West curve. Put differently, the Northeast-Midwest curve lies under the South-West curve to the left of the vertical line (where actual spending is less than predicted), and lies above the South-West curve to the right of the vertical line (where actual spending is higher than predicted). In other words, holding base characteristics constant, DoD is spending more on the Northeast-Midwest bases and less on the South-West bases.

Table 13 shows this more simply. A larger percentage of the bases in the South and West are spending in the "lower than predicted" region, and a larger percentage of the bases in the Northeast and Midwest are spending in the "higher than predicted" region.

This result is simply a restatement of the earlier finding in table 9, that DoD is spending 9 percent less on a typical base in the South-West than in the Northeast-Midwest region.

REFERENCES

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